Anomalous Micro-Diffraction from Selective Area Growth InGaAsP Thin Films

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Beamline(s): **X16C**

Introduction: In order to determine the local composition we have performed anomalous micro-diffraction studies of Selective Area Growth (SAG) of quaternary InGaAsP compounds. SAG of the InGaAsP is accomplished by patterning the InP substrate with an oxide mask and then growing a quaternary layer in an MOCVD reaction chamber exactly as one would for an un-patterned film. The metallo-organic growth precursors (e.g., Trimethyl-Gallium) will not stick to the oxide surface, leading to local variations of the reactant concentrations near the growing surface. For each element there is a length scale over which the local concentrations of the 4 elements vary, i.e. an effective diffusion length for each element. For example these effective diffusion lengths are typically 30 microns for In, and 200 microns for Ga. The oxide patterning thus perturbs the local growth rate and composition of the quaternary material, resulting in a strain, thickness and band-gap variation with position.

A model for SAG has been developed. Within the assumptions of this model, one needs only the local strain, determined by X-ray diffraction, and the bandgap determined by photo-luminescence to be able to completely predict the properties such as thickness and composition for any planar geometry. The assumptions include Vegards law, the extrapolation of the bulk elastic coefficients, and infinite diffusion length for As and P .Our previous micro-diffraction measurements of local strain alone, and then subsequently strain and thickness are to be interpreted within the constraints of the model approximations.

Ideally, we would like to have direct experimental values for the strain, thickness and composition at every point, thus providing an assumption-free test of the existing model. In order to do this we have performed Anomalous Micro-Diffraction (AMD) from these quaternary films. Since the substrate consists of InP, this prevents us from using fluorescence to extract the In and P concentration, even though we can determine the Ga and As concentration. In principle, AMD measurements in the vicinity of the (002) and the (004) should help us solve for the concentrations in the quaternary film.

Methods and Materials: The experiment was performed at bending magnet X16C beamline together with a double-crystal Si(111) monochromator. The micro-focus was provided by a compound refractive lens from Adelphi Technologies, with a beam spot of order 5 microns by 30 microns.

Results: Shown in Figure 1 is the intensity at the L=2.012 at the Ga edge, and in Figure 2 at the Arsenic edge. L=2.012 corresponds to a maximum from the thickness fringes due to the quaternary film. Measurements were also made in the vicinity of the (004). The films are nominally an InP(substrate), quaternary (350A), InP (500A) sandwich. The analysis of this data is in progress.

Conclusions: Clearly the signal levels present in the data, even for such a small amount of material (350angstrom x 5 micron x 30 micron) are large enough to permit an attempt at a solution.

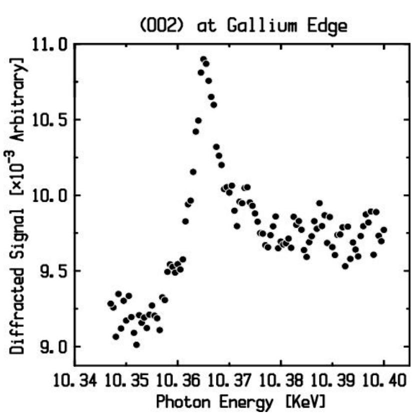

Figure 1. Intensity at L=(0,0,2.012) in the vicinity of the Ga edge.

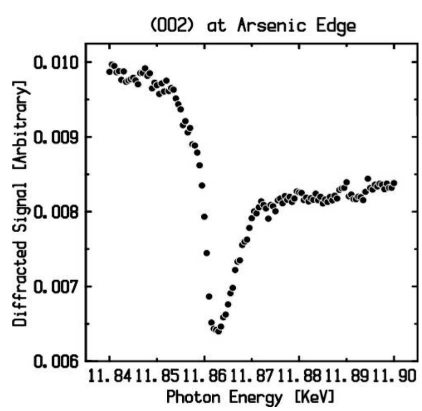

Figure 2. Intensity at L=(0,0,2.012) in the vicinity of the As edge.